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QUANTITATIVE ASSESSMENT OF THE SLOPE RESOLUTION OF SEAFLOOR MAPPING SYSTEMS

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QUANTITATIVE ASSESSMENT OF THE SLOPE RESOLUTION OF SEAFLOOR MAPPING SYSTEMS, FY '91 ACTIVITIES

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OBJECTIVE

Creation of deterministic bottom roughness data sets for the Atlantic and Pacific.

BACKGROUND

Even as the ARSRP approaches mid-life, considerable uncertainty still exists over the relative importance of sediment-covered vs. hard rock acoustic bottom interaction. The acousticians are still trying to decide which sets of physics to include in their equations. We have endeavored to provide the most detailed near-bottom information now on hand to describe the situation on the flanks of the Mid-Atlantic Ridge. We have also continued our efforts in the 350x300 km ONR Pacific Natural Laboratory, so that we can provide a fast-spreading rate comparison to the North Atlantic Natural Laboratory corridor, when the ARSRP geophysical cruise data become available.

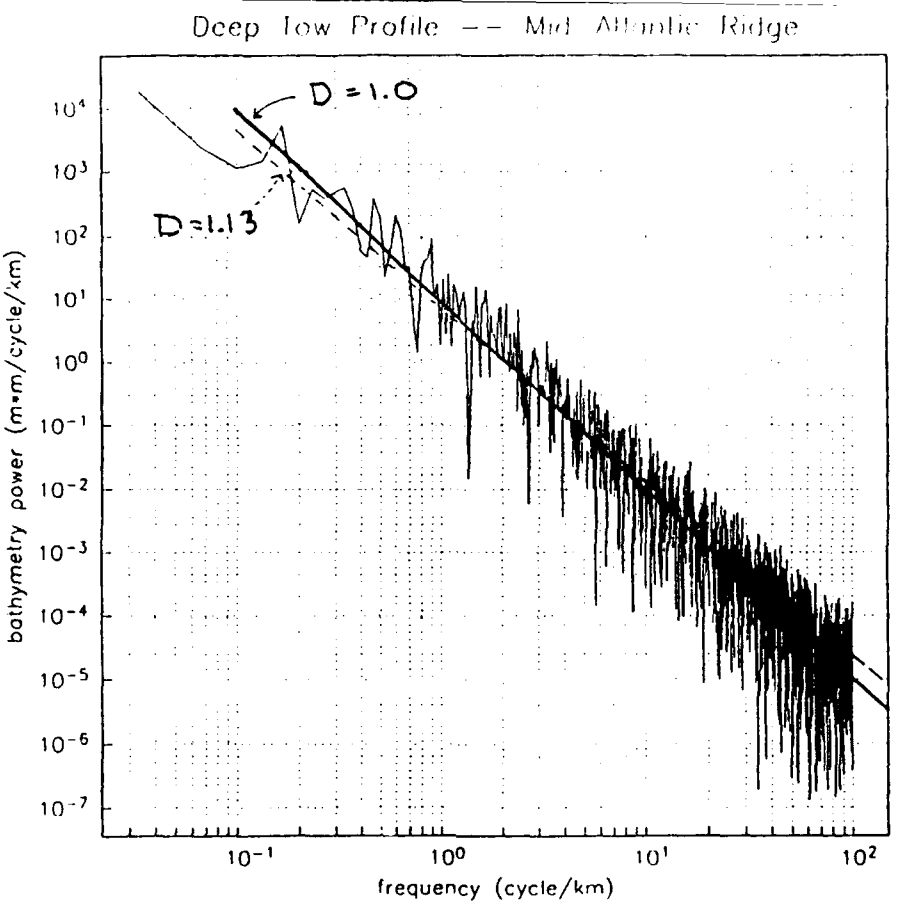
APPROACH

The depth to the seafloor and the sediment thickness were observed with the SIO-MPL Deep Tow system from an altitude of 100 m on the western flank of the Mid-Atlantic Ridge near the FAMOUS area, 37 N, providing what is probably the most appropriate high resolution data set available at this time for roughness studies of the abyssal hill terrain of the Western North Atlantic. We have re-analyzed the original Deep Tow sonar record at a 3-m horizontal sample spacing. We have also synthesized all the available bathymetry data in the ONR Pacific Natural Laboratory near 9 N on the EPR, keeping close track of the statistical differences between measurements from a number of vessels and sonar systems. Most of the effort in the Pacific has been supported by the Marine Geology and Geophysics Program of ONR, but the results are available to the ARSRP and the analysis methods can be applied to the Atlantic data.

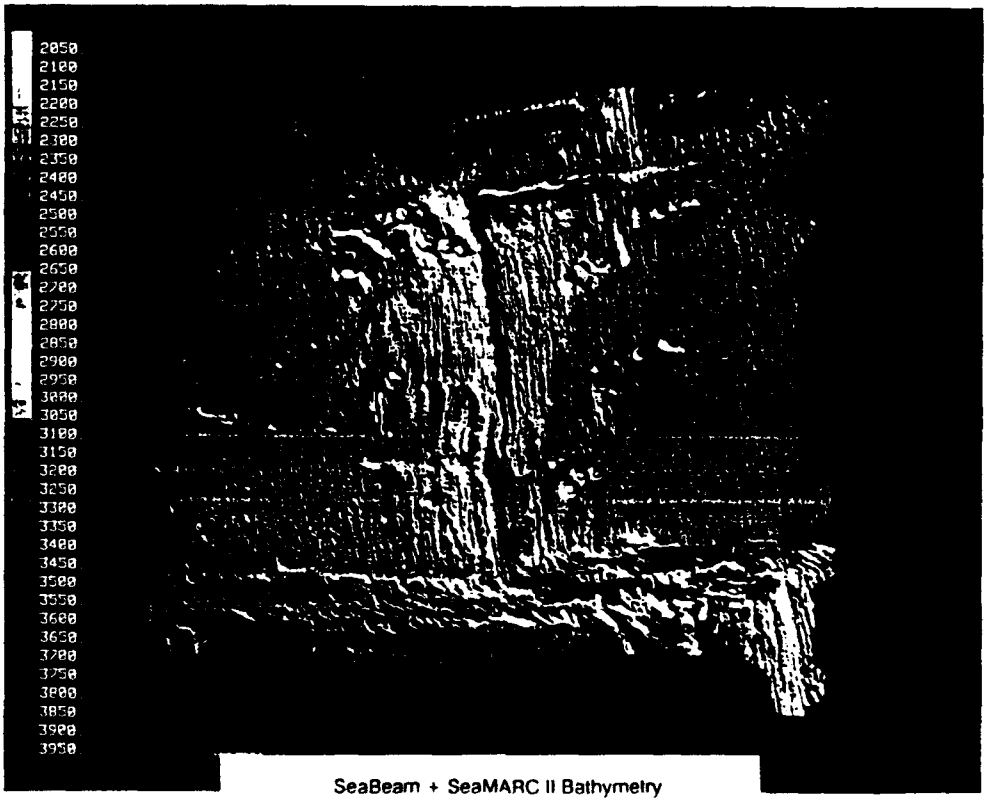
RESULTS

Along the MAR Deep Tow profile, individual sediment ponds of thickness up to 15 m are detected, although approximately half the profile has less than 1 m of sediment cover. A histogram of the original data shows that 77 percent of all slopes are less than 22 degrees, but 3 percent are greater than 71 degrees. The fall-off of the power spectrum is consistent with a fractal dimension D = 1.0 over the wavelengths 8 km to 10 m. Both Dougherty and Levander have computed the reverberant wave field for sections of this deterministic model of the seabed. The results are significantly different from the wave field computed from the model in current use in the ARSRP, which is based on extrapolation by Goff-Jordan statistical techniques. The observed bathymetry at 37 N on the MAR is much smoother than the extrapolated model.

The swath mapping sonar data in the Pacific Lab were gridded at a 300 m grid spacing. The rms depth mis-fit between SeaBeam track lines over the grid is typically about 15 m. Systematic depth offsets of up to 40 m were found between SeaBeam and SeaMARC II bathymetry, presumably due to flat-bottom table approximations. To construct a consistent map, SeaMARC II port and starboard data are gridded separately, and then combined with the existing SeaBeam with a best least-squares trend fit. The resulting rms mis-fit between SeaBeam and SeaMARC II data is approximately 40 m. The area exhibits very strong relief in transform faults, and wide variations in abyssal hill fabric orientation and amplitude, which greatly influence the azimuthal dependence of low frequency acoustic backscatter.



A spectral fall-off consistent with a fractal dimension D = 1.0, over the wavelengths 8 km to 10 m, is obtained from near bottom observations on the flanks of the MAR at 37 N.



SeaBeam + SeaMARC II Bathymetry

CNR Pacific Geological/Acoustical Natural Laboratory

East Pacific Rise 8-10 N

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B. Publications

1. ONR-SUPPORTED FY 91 PUBLICATIONS:

Carbotte, S.M., S.M. Welch and K.C. Macdonald, Spreading rates, rift propagation and fracture zone offset histories during the past 5 my on the Mid-Atlantic Ridge; 25 - 27 30'S and 31 -34 30'S, Mar. Geophys. Res. 13:51-80, 1991.

Fox, P.J., N.R. Grindlay, and K.C. Macdonald, The Mid-Atlantic Ridge (31 S-34 S): Temporal and spatial variations of accretionary processes, Mar. Geophys. Res. 13:1-20, 1991.

Grindlay, N.R., P.J. Fox and K.C. Macdonald, Second-order ridge axis discontinuities in the South Atlantic: Morphology, structure and evolution, Mar. Geophys. Res. 13:21-49, 1991.

Macdonald, K.C. and P.J. Fox, The mid-ocean ridge, Scientific American 262:72-79, 1990.

Macdonald, K.C., A slow but restless ridge, Nature 348:108-109, 1990.

Macdonald, K.C., Mid-Ocean Ridges: The Quest for Order, (introduction to special issue on Mid-Ocean Ridges), Oceanus, 34, 9-10, 1991.

Macdonald, K.C., D.S. Scheirer and S.M. Carbotte, Mid-ocean ridges: Discontinuities, segments and giant cracks, Science 253:986-994, 1991.

Miller, S.P., 3-D Bathymetric Imaging: State of the Art Visualization, Sea Technology, 32, cover and 27-32, 1991.

Tucholke, B.E. K.C. Macdonald, and P.J. Fox, ONR seafloor natural laboratories on slow and fast-spreading mid-ocean ridges, EOS Trans. AGU 72:268-270, 1991.

2. BOOK CHAPTERS:

Macdonald, K.C., Mid-oceanic ridge, in Parker, S.P., ed., McGraw-Hill Yearbook of Science & Technology, 1992, New York: McGraw-Hill, Inc., 259-262, 1991.

3. (NO PATENTS)

4. INVITED PAPERS:

Miller, S. P., 3-D Bathymetric Imaging: State of the Art, Oceans '91 Conference, IEEE, Honolulu, Hawaii October 1991.

5. GRADUATE STUDENTS:

Suzanne Carbotte

Thesis will combine both observational and theoretical techniques. Thesis objective is to examine variations in seafloor tectonic fabric with spreading rate and proximity to ridge axis discontinuities in light of constraints these patterns provide on crustal accretion processes. Study areas include portions of fast, (East Pacific Rise at 8-10 N),medium (Ecuador Rift) and slow spreading ridges (Mid-Atlantic Ridge between 25 and 27 S). Data used are high resolution bathymetric data (SeaBeam and SeaMARC II), side-scan sonar data (SeaMARC II). Complementary magnetic studies of ridge-axis discontinuities within these areas have been carried out. Canadian nationality. Thesis defense scheduled for February 4, 1992.

Marie-Helene Cormier

Thesis will combine both observational and theoretical techniques. Thesis objective is to constrain the processes at or near ridge axis discontinuities for ultra-fast spreading rates. Study area is located between 18 S and 22 S on the EPR. Tectonic history of the discontinuities will be studied using high resolution bathymetric data (SeaBeam and SeaMARC II), side-scan sonar data (SeaMARC II) and magnetic data. Sub-crustal processes will be constrained with three-dimensional gravity analysis technics. French nationality. Anticipated date of graduation is end 1992.

Daniel Scheirer

Thesis will combine both observational and theoretical techniques. Thesis objective is to study large-scale accretionary processes along the East Pacific Rise and the Mid-Atlantic Ridge. In particular the processes responsible for the occurence of the "gravity rolls" on the west flank of the EPR between 16 and 19 S will be investigated and also those which might explain the evolution of the MAR in the South Atlantic. Data used will be high resolution bathymetry (SeaBeam and SeaMARC II), Seasat altimetry, gravity and magnetics. American nationality. Anticipated date of graduation is summer 1993.

Charles Weiland

Thesis will combine both observational and theoretical techniques. Thesis objective is to investigate the tectonic history of the complicated ridge axis discontinuities at both fast and slow spreading centers. Study area comprises the OSC at 16 N on the EPR, and several sites on the Mid-Atlantic Ridge Data used will be high resolution bathymetry (SeaBeam and SeaMARC II), Side-scan sonar (SeaMARC II), magnetic and gravity. American nationality. Anticipated date of graduation is Summer 1993.

6. PAPERS SUBMITTED OR IN PRESS

Macdonald, K.C., P.J. Fox, S.P. Miller, S.M. Carbotte, M. Edwards, M. Eisen, D. Fornari, R. Haymon, L. Perram, R. Pockalny, D. Scheirer, S. Tighe, and C. Weiland, The East Pacific Rise and its Flanks 8-18 N: History of Segmentation, Propagation and Spreading Direction Based on SeaMARC II and SeaBeam Studies, Mar. Geophys. Res, in press, 1991.

7. (NO PATENTS PENDING)

8. PRESENTATIONS AT MEETINGS

ONR-Supported Published Abstracts:

1990

Macdonald, K.C. and D.S. Scheirer, Why long segments lengthen at the expense of short segments, EOS Trans. AGU 71:1629-1630, 1990.

Carbotte, S.M. and K.C. Macdonald, Evolution and history of the OSC at 9 03'N from three-dimensional analysis of magnetic data, EOS Trans. AGU 71:1629, 1990.

Weiland, C., D. Scheirer, K. Macdonald and D. Forsyth, Changes in ridge segmentation in the S. Atlantic, EOS Trans. AGU 71:1628, 1990.

1991

Carbotte, S.M. and K.C. Macdonald, Comparison of sea floor tectonic fabric created at intermediate, fast and ultra-fast spreading ridges, EOS Trans. AGU 72:456, 1991.

Miller, S. P., Adventures in Combining Large Scale SeaBeam and SeaMARC II Bathymetric Surveys, Oceans '91 Meeting, Oct 1-3, 1991, Oceanic Engineering Society of the IEEE, Honolulu, Hawaii, Proceedings, vol 2, 764-766, 1991.

Miller, S.P., K.C. Macdonald C.M. Weiland and D.S. Scheirer, SeaBeam + SeaMARC II map series: EPR 7 -18 N, EOS Trans. AGU 72:495, 1991.

Macdonald, K.C., The East Pacific Rise south of Garrett:Volcanic activity predicted for 14 -14 30'S, EOS Trans. AGU 72:506, 1991.

Macdonald, K.C., S.M. Carbotte, S.P. Miller, L.J. Perram, D.S. Scheirer, C. Weiland, D.S. Wilson, R. Pockalney, P.J. Fox and C. Nishimura, Sea Beam/SeaMARC II survey of the EPR 7 50'-10 30'N to establish an ONR "Natural Laboratory", EOS Trans. AGU 72:495, 1991.

Pockalney, R., P.J. Fox and K.C. Macdonald, Generation of volcanic transverse ridges along the Siqueiros Fracture Zone, EOS Trans. AGU 72:491, 1991.

Scheirer, D.S. and K.C. Macdonald, Variation of the axial cross-sectional area along the northern and southern East Pacific Rise, EOS Trans. AGU 72:506, 1991.

Weiland, C.M., D. Scheirer and K.C. Macdonald, Mid-Atlantic Ridge 31-36 S: Segmentation evolution, EOS Trans. AGU 72:452, 1991.

Miller and Macdonald, UCSB, FY '91

9. (NO TECHNICAL REPORTS)

10. CONFERENCES ATTENDED

Oceans '91, October 1991, Honolulu
Fall '91 AGU, December 1991, San Francisco

C. TRANSITIONS

UCSB site visit by Dr. Robert Lorens, Nav Oceano, regarding seafloor mapping strategies, GIS systems, near real-time combination of bathymetry and backscatter, present Navy hardware and software capabilities and future needs. Special Projects Div., Nav Oceano Bay St. Louis, MS, 601-688-4145

UCSB site visit by George Powell and 5 other investigators from Rockwell, regarding UCSB implementation of GIS techniques for submersible diving programs and seafloor mapping, to be applied to Navy autonomous vehicle program development, Nov 25, 1991.

Numerous discussions on seafloor mapping, 3-D visualization, hardware and software developments, with John Williams, SSI Inc, Honolulu, Hawaii, 96822

Numerous discussions and site visits with SeaBeam Instruments, Westwood, Mass, regarding swath mapping hardware and software, Rob Carlson, CEO, 1-800-SEABEAM.

Participated in Ocean Mapping Workshop, Oct 4, 1991, at Pacific Mapping Center. Advice on computing platforms, software capabilities, personnel and mapping strategies, related to the founding of the Pacific Mapping Center, funded by USGS, State of Hawaii, NOAA, etc, Narenda Saxena, Director, Dept. Engineering, Univ Hawaii, 808-956-2376.